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## Water Conservation and Florida's Green Swamp

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Green Swamp covers about 800 square miles of Lake, Pasco, Sumter, and Polk counties. Although every swamp contributes something to making a continuous supply of fresh water available for human consumption, the fact that Green Swamp plays a strategic role in supplying water for a rapidly growing population in most of Central Florida has only recently been recognized by anyone except specialists. For this reason it warrants special attention. This article consists of a statement of the functions of swamps and an account of how Floridians have used them, together with an evaluation of how Green Swamp can be developed to facilitate the state's economic growth in the future.

Swamps are unique combinations of land and water resources. They occur on the portions of the earth's surface that are covered with soils capable of absorbing large amounts of water and from which water does not rapidly drain. In most instances these soils have a high organic matter content and are frequently called muck.

The water that generally saturates and sometimes covers swampland at any one time is passing through the hydrologic cycle. It has just arrived on the earth's surface in the form of rain, and is on its way back to the ocean. Some of it runs into small streams that flow into the creeks and rivers and reaches the ocean within a few days or weeks. The balance, and often a large portion of it, filters through the earth's surface into the pores of permeable geologic formations. Later, water withdrawn from these formations through wells and springs may be used one or more times before it is returned to the ocean via streams or to the atmosphere via evaporation. The remainder either remains in the formations or flows back to the ocean through openings in the ocean floor. The geologic formations in which fresh water is stored beneath the ground are called aquifers.

### Underground Water Storage

Most of the aquifers in which Florida's supply of fresh water is stored are of two general types, water table and artesian. In water table aquifers, water seeks a common level throughout the whole formation, whereas the water stored in artesian aquifers is under pressure at many places and these pressures vary from one location to another. Hence, water stored in artesian aquifers can flow freely from springs and wells.

Ground water in Broward and Dade counties and most of the Everglades is stored under water table conditions in the Biscayne aquifer. The height of the water table within the aquifer is determined by the amount of rainfall, rising during the rainy season and falling during the dry spring months. This aquifer produces very large but not unlimited quantities of fresh water. At the present time it supplies essentially all of the fresh water used in the two counties.

The remainder of the land south of Lake Okeechobee is underlain with a number of aquifers, some of which are water table and others, artesian. The shallow water table structures produce limited supplies of fresh water, whereas the deeper artesian aquifers produce very large volumes with chloride and sulfur contents that make it useless to human beings.

Practically all of the remainder of the state's freshwater supply is stored in a very large artesian type formation called the Floridian aquifer. This is a thick limestone structure, the surface of which is near the earth's surface along the Gulf coast from Tampa to near Panama City and rises to its highest elevation over a rather large area just east of Tampa in South Florida and in South Georgia beneath the Okefenokee Swamp. In Santa Rosa and Escambia counties and the area southeast of St. Augustine this aquifer is overlain with a number of small aquifers, generally of the water table type.

When Florida became a state in 1845 roughly half of the land covering these aquifers was capable of absorbing large amounts of water that did not drain away, i. e., had the basic attributes of a swamp. When Congress passed the Swamp Lands Act in 1850, the state acquired a public domain that was estimated to consist of approximately 14 million acres. This estimate was later revised upward to nearly 20 million acres. At the time, much of this land was serving the function of keeping the state's freshwater storage facilities—i. e., the aquifers—full and often overflowing. In more technical terms, the swamps were recharging the aquifers at a rate that generally equalled

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and often exceeded the rate water was being withdrawn from them. However, the water that generally filled the pores of, and sometimes covered, swampland seriously limited its usefulness for other purposes. In other words, water resources are an inseparable part of land resources and the utilization of one affects the utility of the other. Florida's economic growth during the past 110 years closely parallels the progress that has been made in making use of these closely related resources.

### Water Management

The potential productivity of the land acquired under the Swamp Lands Act was quickly realized by the state legislature. In 1855 the custody of this land was given to the trustees of an Internal Improvement Fund—a fund created for the purpose of promoting economic activity in the state by sponsoring the construction of such projects as railroads and canals. After some of their early projects failed, the trustees tried to sell land at bargain prices to buyers who would agree to reclaim it by constructing drainage facilities. In 1877, the fund became bankrupt but continued to sell land through a receivership in an effort to pay off its debts.

Hamilton Disston, the wealthy son of a Philadelphia saw manufacturer, was the first man who had definite ideas about how to utilize South Florida swampland and enough money to try them out. In 1881 he contracted to buy four million acres of land north and west of Lake Okeechobee for one million dollars. This sale enabled the trustees to pay the debts of the Internal Improvement Fund. Although the Disston water control project stopped after his death in 1896, the original transaction freed the hands of the trustees of the Internal Improvement Fund to promote similar projects and demonstrated the problems that might be encountered in completing them. Three years later, the United States government began to study the desirability of developing the area.

When Napoleon Bonaparte Broward became Governor of Florida in 1900, all of the reclamation projects that had been undertaken up to that time had not appreciably affected the land-water balance in peninsular Florida. Lake Okeechobee still had an elevation of approximately 20 feet above sea level, and the lower east coast had a population of less than 5,000 people.

In 1907, the state legislature created the Everglades Drainage District and defined its boundaries. This agency was directed to drain and reclaim the land within these boundaries with the money accumulated from a 5-cent-per-acre annual tax. In 1913, the district was reorganized and refinanced, and between 1913 and 1927 enough canals, levees, locks, and dams were constructed to make the production of agricultural commodities possible over a wide area. People began to settle south of Lake Okeechobee almost as soon as the work began, and as early as 1921 approximately 2,000 people were farming near the lake. During this period an agricultural experiment station was established at Belle Glade to solve production problems unique to the area.

The hurricanes of 1926 and 1928 brought the work of the Everglades Drainage District to an abrupt halt. These storms demonstrated that drainage alone was not enough to make swampland habitable and productive, and this fact together with the collapse of the Florida land boom (which undermined the financial structure of the Everglades Drainage District) made a re-evaluation of the project necessary.

In 1929, the state legislature created the Okeechobee Flood Control District and directed it to work with the Corps of Engineers of the United States Army in the erection of flood control structures in the Everglades. At this time the federal government, which heretofore had been interested only in developing the navigation potential of the area, began to take an active part in flood control projects. While this work was underway, (1) the lack of rainfall, (2) an increase in the rate at which surface water was being removed from the Everglades, and (3) an increase in the rate at which water was being removed from the aquifer to supply a rapidly growing population along the lower east coast resulted in salt water intruding into the eastern edge of the Biscayne aquifer. Salt-water intrusion, together with the drought of 1945 and the hurricane of 1947, made it obvious that draining swampland and protecting the drained land from floodwater damage would not cause this land to make its full contribution to the economic growth of the state. Nevertheless, enough information had been accumulated on how to control the water in the swamp to design a project that would actually accomplish the ends that Floridians had been striving to achieve for an entire century. More precisely, it made clear the feasibility of managing water in swamps to facilitate the production of such diversified products as wildlife, recreation, and agricultural crops, and at the same time permit enough water to filter through the earth's surface to recharge the aquifer with a supply of fresh water for the people living in the coastal cities.

The Central and Southern Flood Control project now being financed by the local, state, and federal governments, is designed to keep water in a usable condition as long as possible. By draining water from some of the swampland in the Kissimmee River watershed and the Everglades, and storing it in lakes or swamps that will enable it to recharge the aquifers, more than two million acres of land will be made more productive. When the project is complete there will be three storage reservoirs southeast of Lake Okeechobee in which the water tables will be as high as or higher than those prevailing in that area before the turn of the century. Here it must be pointed out that the St. Johns marsh is a part of another watershed and hence must be managed quite differently than the Kissimmee watershed. In fact the need for an organization to manage the water in the entire St. Johns River basin is becoming more and more apparent.

It was obvious that the water in the swamps of South Florida and particularly the Everglades had to be managed before the land could be utilized, but the need for managing swamps in other parts of the state was more obscure. In the central and northern portion of the peninsula, it was possible to make a relatively large amount of land productive by the application of fertilizer and water on comparatively small tracts. In this area the cost of water control projects was relatively low, and in many instances individuals or relatively small groups of land owners were able to finance and construct their own water control facilities. Many artesian wells were drilled in Osceola, Orange, Seminole, Volusia, and surrounding counties. The water that flowed freely from these wells was applied to the land through networks of ditches or tile at the rate needed for the production of crops. These facilities were augmented, at a somewhat higher cost, by shallow lift pumps that removed water from the aquifer and numerous lakes in locations where artesian water was not available. In recent years, water has been applied to the land through overhead sprinkler systems as well as through open ditches and tile used in the first projects. In many instances these privately developed water control systems included dykes constructed for the purpose of excluding run-off water from immediately adjacent lands, especially during the rainy season.

Only recently has the effect of this random and unplanned utilization of the water in Florida's natural fresh-water storage facilities, both surface and subsurface, been observed. The intrusion of salt water into wells along the coasts, both east and west, was undeniable evidence of the fact that the fresh-water supply of the state was being mismanaged. The intrusion of salt water into the the water table formations overlying the edge of the Floridian aquifer can be the result of a number of factors including (1) using fresh water more rapidly than it is supplied by the hydrologic cycle, (2) excessive drainage of the swamps, (3) the lack of structures to prevent salt water from entering drained land through canals, and (4) the concentration of wells in one part of an aquifer that results in withdrawing water more rapidly than it can flow in from other parts of the formation.

Since the state receives an average daily rainfall of about 150 billion gallons of water and uses less than 4 billion gallons, it is obvious that the hydrologic cycle is providing enough fresh water to supply the needs of a rapidly expanding economy. Salt-water intrusion and any long-run fall in the artesian pressure in specific locations are due to the lack of management.

Little can be done about stabilizing variations in the amount of rainfall. The construction of protective structures along the coast can retard the rate of salt-water intrusion, but they do not offer an effective means of conserving any substantial portion of the water supply.

The long-run decline in the height of the water table in several areas, and especially along the coast, demonstrates the need for local water management projects. Since rain water is most economically managed in natural watersheds, water management projects are underway in several river valleys, including the Oklawaha, Suwannee, and Peace. Other projects are being undertaken in areas less than an entire river basin. Water management projects that cover minor watersheds are feasible and many of them are either receiving or are eligible to receive federal assistance. On the other hand experience has clearly shown that water management projects based on political rather than natural boundaries generally fail.

River basin projects are most effective in controlling water while it is on the surface and in facilitating the recharge of portions of the aquifer. However, river basin boundaries do not define aquifers. This is particularly true in Florida where six major and numerous small watersheds drain water off the surface of the Floridian aquifer. Since the water stored in the Floridian aquifer moves freely under watershed boundaries, full utilization will require the use of some conservation practices that extend over two or more watersheds.

The law requiring that all artesian wells be capped was enacted to conserve the water stored in the Floridian aquifer as a whole rather than under any particular watershed. Compliance with this law will retard the rate at which pressures in some artesian wells are dropping but will not necessarily maintain the pressures that now prevail. Artesian well pressures are determined by the relationship that exists between the rate of recharge, the movement of water within the aquifer, and the rate of withdrawal. Hence, with a constant rate of withdrawal artesian pressures fluctuate with rainfall. On the other hand if the rate of withdrawal is consistently higher than the rate of recharge, the pressures will continue to fall. This, coupled with the fact that it takes time for pressures to equalize throughout the aquifer, suggests that some regulation of the location of new wells may be needed to balance the use of the fresh-water supply of the state.

## Green Swamp

The most urgent need for managing the supply of water entering the Floridian aquifer is in the west central portion of the peninsula. In northern Polk, western Pasco, and southern Lake and Sumter counties there is a tract of land consisting of approximately 800 square miles in the form of a shallow pan. Of this 800 square miles, approximately 200 square miles are generally if not permanently inundated and the remainder consists of a series of interconnected swamps and sandy ridges. Within this area, generally known as Green Swamp, four major rivers rise: the Withlacoochee flowing northwest, the Oklawaha flowing northeast, the Peace flowing south, and the Hillsborough, west. The flow of these streams is closely related to the rate of rainfall.

Green Swamp lies directly over a nonartesian or water table type aquifer composed of sand and clay which receives the water that filters down from the swamp and discharges it into the Floridian aquifer that lies just below it. The fact that Green Swamp recharges the Floridian aquifer where its pressures are the highest gives it a unique role in the maintenance of the state's underground water supply.

Green Swamp is the only recharge area that can supply the water needed to maintain existing pressures within the Floridian aquifer and particularly in the peninsula. It is more than a coincidence that the route that has been selected for the cross state barge canal follows a line of low artesian water pressures extending from Jacksonville to the mouth of the Withlacoochee.

The importance of keeping this swamp in a condition that will enable it to continue to recharge the aquifer at the same rate it has in the past lies in the need for maintaining the ground-water supply in the southern part of the peninsula at as near constant levels and pressures as possible. Or, stated in another way, any decrease in the artesian water pressures in the aquifer immediately under Green Swamp will jeopardize the entire ground-water supply of the state south of Ocala. Any reduction in the amount of water stored in the southern portion of the Floridian aquifer will in turn limit the economic growth of Florida.

In designing water control structures and in managing the water that falls on Green Swamp, it must be remembered that Green Swamp and the Everglades serve essentially the same function in the hydrologic cycle in that they recharge aquifers that are essential to the economic well-being of the state. The similarity of the two areas was recognized long ago when people began to call Green Swamp the "Little Everglades." Geologists and engineers now recommend that programs, similar to those now underway in the Everglades, be taken to preserve the ability of Green Swamp to recharge the aquifers it overlays, but the specific structures differ in important detail.

The Corps of Engineers, the United States Geological Survey, and the Florida Department of Water Resources are now conducting studies dealing with the kind and the location of the physical structures needed to achieve the multi-purpose objectives of (a) recharging the aquifer, (b) facilitating the production of agricultural products, (c) controlling floods, and (d) maintaining a favorable environment for recreation in Green Swamp and the surrounding area. Within a reasonable period of time a plan that is physically feasible will be forthcoming.

But it will be more difficult to put any plan for the conservation of Green Swamp into effect than it was to construct the conservation areas now existing over the Biscayne aquifer in the Everglades. There are three reasons for this. In the first place, the distance any excess water falling on Green Swamp must be transported to the ocean is greater than the distance water must be transported from the Everglades. The fact that the fall is greater, more than 100 feet in most places, compared with a fall of about 15 feet in the Everglades, calls for the construction of large surface water reservoirs between Green Swamp and the ocean. Because the fall in the Everglades was so small, it was necessary to install pumps to assist gravity in removing the water.

Second, the water in the major streams that rise in Green Swamp is used by many people in many ways before it reaches the ocean, whereas the water removed from the Everglades is used very little. Any plan to control the water in Green Swamp must be devised with full consideration of the effect it will have on the flow of these streams as this is related to their recreational and economic uses.

Finally, large areas within Green Swamp, particularly the hammocks, are now in agricultural use, whereas essentially no use was being made of the portion of the Everglades that was converted into water conservation areas. Furthermore, each year more land within the swamp is being drained and used, thus reducing the rate at which the aquifer is being recharged. This in turn is lowering the water table under the hammocks within the swamp. To the extent that the conservation plan prevents an owner from using his land, he is entitled to compensation. Nearly all of the land in the swamp is in private ownership and much of it used, in some cases quite extensively. Hence the compensation due land owners for either current or anticipated loss may cost the public more than the physical facilities needed to actually control the water.

In an effort to delineate State policy with respect to the conservation of Green Swamp and resolve the many problems encountered in carrying it out, four things have already been done: (1) the Department of Water Resources has recommended the preservation of Green Swamp as a means of protecting the fresh-water supply, (2) the 1961 Legislature implemented this policy by passing the necessary enabling laws, (3) the people living in the areas have in turn created river basin organizations in some of the major watersheds and, (4) the Southwest Florida Water Management District has been organized.

The role that the Southwest Florida Water Management District will play in conserving the water stored in the Floridian aquifer is unique in that its authority extends over the headwaters of four major and a number of minor rivers. The rate at which any water not needed to recharge the aquifer is premitted to flow to the ocean through these rivers vitally affects the economic well-being of people living in these watersheds as well as the quality of the recreational environment. The floods in 1959 and 1960 clearly demonstrate the magnitude of this effect. For this reason the conservation program of the watershed authorities in the area will be related to the program of the Southwest Florida Water Management District. Once the district adopts a management plan it will be possible to estimate the amount of water that will be discharged into each of these rivers from retaining structures at the edge of the swamp. On the basis of this, the watershed authorities can erect structures outside of the swamp to regulate this flow to facilitate economic growth within their respective boundaries. Recent floods lend urgency to flood control structures, but the same structures that make it possible to control floods can make large amounts of fresh water available during period of drought.

The technical knowledge to conserve Florida's fresh-water supply is generally at hand. Of course, research will provide more knowledge but the application of the knowledge now available will conserve all of the water needed in the state in the forseeable future. The extent to which Green Swamp is actually developed as a water conservation area depends almost entirely upon the amount of money available for the work. As yet, the total cost of the undertaking has not been estimated. When current studies are complete and estimates made, the figure will seem to be large. Regardless of what the cost is it will be a bargain in that it will never be possible to do the job any cheaper and the need for water increases with the birth of every baby and every industry. California is now paying the price for not beginning to manage its water supply soon enough. The people of that state have just authorized a bond issue of roughly one and three-quarter billion dollars to finance the construction of facilities to transport water from the northern part of the state hundreds of miles to satisfy the needs of people living further south. This was necessary because the residents of southern California have overdrawn their ground water supplies and thus seriously limited the rate of economic growth in that area until more fresh water can be made available.

The studies now underway on Green Swamp and the surrounding area are prima facie evidence that Floridians have enough foresight to at least begin to develop a rational and progressive policy with respect to water utilization. No matter how meritorious the results of these studies may be, they can be no more successful than the measure of public support given them.